Astrometric Measurements of the Visual Double Star H 5 12AB

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Abstract: As part of the fall 2009 astronomy research seminar at Cuesta College, high school and undergraduate students made observations of the visual double star H 5 12AB. They measured the angular separation to be 40.4" with a standard deviation of 4.6". They measured the position angle to be 44° with a standard deviation of 3°. The students then determined that the double star is likely gravitationally bound because the proper motion vectors of the primary and secondary stars only differ by ~2.5°.

Introduction

The fourth fall 2009 astronomy research seminar at Cuesta College consisted of students from Arroyo Grande High School, California Polytechnic State University, Cuesta College, Hancock College, and University of California, Chico. They met with the instructor, Genet, at Cuesta College for observation planning and guidance. Some students with prior experience in measuring double stars acted as team leaders to the students making their first quantitative measurements (Genet et al 2010).

This project had three goals in mind:

1) Give new students the opportunity to make their first quantitative measurements while providing returning students with the opportunity to lead the project. Visual double stars make ideal targets for students because the concepts are relatively straightforward, the equipment is affordable, and the skills they learn—quantitative statistical analysis, experiencing the peer review process, publishing a paper in a journal, and reporting their results at a symposium—are directly applicable to masters theses and doctoral dissertations (Johnson 2008).

2) Contribute observations of a double star. The students chose H 5 12AB because of its ideal location in the sky (RA: 01h 57m 55.71s Dec: +23° 35m 45.8s) and its relatively bright primary and secondary magnitudes (4.8 and 6.65, respectively).

3) Use proper motion vectors to determine if the double star is an optical pair or a gravitationally bound binary system.

Equipment and Procedure

Estrada provided a 10-inch, f/6 German equatorial mounted reflector with a tracking motor. A Celestron 12.5mm Micro-Guide eyepiece was used for all observations. Drift timings were made with a stopwatch

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Figure 1: Research seminar students and instructor pose during their analysis of the double star data. An outline of a research paper can be seen on the whiteboard behind them.

which read to 0.01s. All observations were made on October 25, 2009 (B2009.8153) at Weise's parent's property east of Arroyo Grande.

Calibration

The observers calibrated the linear scale of the eyepiece once Estrada polar aligned the telescope. The observers selected a star with a declination between 60° and 75° so it would not drift either too slowly or too quickly to get a precise time (Teague 2004). The star was set at the east end of the field of view and was allowed to drift parallel to the linear scale when the right ascension motor was turned off. Each observer started the stopwatch when the star hit the first division and ended it when the star hit the last division. The students made 14 trials and recorded the time to the nearest 0.01s. The times were averaged and used in the equation:

$$Z = \frac{15.0411\, t \cos\delta}{60}$$

where Z is the scale constant in arc seconds per division, 15.0411 is the number of arc seconds per second that the Earth rotates, t is the average time it took for the star to drift across the linear scale, δ is the declination of the star, and 60 is the number of divisions along the linear scale.

The students used β Cassiopeia which has a declination of 59° 08m 59s. The average drift time was 104.86 seconds. This yielded a scale constant of 13.48"/div with a standard deviation of 0.08"/div and a standard error of the mean of 0.02"/div.

Separation

To measure the angular separation, the observers aimed the telescope at the target star and rotated the eyepiece so the linear scale was parallel to the double star. The observers counted the number of divisions to the nearest 0.1 division and recorded the trial. To reduce observing bias, the telescope was moved so that the primary star was at a different spot along the linear scale after each trial (Frey 2010). The number of divisions for each trial was then multiplied by the scale constant (Z) to determine the angular separation in arc seconds. 14 trials were made with an average of 40.4", a standard deviation of 4.6", and a standard error of the mean of 1.2".

Position Angle

The position angle was measured using the drift method (Teague 2004) where the primary star was positioned in the exact center of the linear scale. The eyepiece was rotated so that the secondary star was on the linear scale. The right ascension motor was then turned off and the star drifted to the outer protractor in the eyepiece. The angle that the primary star passed was estimated to the nearest degree and recorded. 14

Figure 2: Vera Wallen looks through Chris Estrada's telescope at dusk.

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Figure 3: Chris Estrada, Vera Wallen, and Eric Weise look at star charts to find H 5 12AB.

trials were made with an average of 224° with a standard deviation of 3° and a standard error of the mean of 1°. The students later applied the position angle correction for the Celestron eyepiece (Teague 2004), giving a final position angle of 44°.

Analysis and Discussion

The measured separation of 40.4” was 3.3” (8.2%) more than the last reported value of 37.1” (Mason 2010) and within the standard deviation of 4.6”. The measured position angle of 44° was 3° less than the last reported value of 47° (Mason 2010), one standard deviation less.

The proper motion vectors reported in the Washington Double Star (WDS) Catalog show that the primary star is moving -92 milli-arc seconds per year in right ascension and -14 milli-arc seconds per year in declination. The secondary star is moving -91 milli-arc seconds per year in right ascension and -18 milli-arc seconds per year in declination. This difference of only ~2.5° strongly suggests that the two components are moving together in space as a gravitationally bound binary system (Arnold 2010).

In completing this project, the students learned how to set up and operate a telescope and measure double stars. In this effort, they dealt with many of the challenges facing astronomers including unusually cold, late nights, re-weighting a telescope to compensate for backlash, and star hopping to their target. They also calculated the scale constant and conducted a statistical analysis of their data, each of which applied mathematics they learned in school. Finally, the project allowed the students to communicate their results both through writing a scientific paper and presenting their results at a special seminar where both students and teachers heard their presentation.

References

Arnold, Dave. 2010. Considering proper motion in the analysis of visual double star observations. In *Small Telescopes and Astronomical Research*, eds. R. Genet, J. Johnson, V. Wallen. Santa Margarita, CA: Collins Foundation Press.

Frey, Thomas G., Johnson, Jolyon M., Almich, Christopher J., and Genet, Russell M. 2010. Visual double star measurements with equatorial and alt-azimuth telescopes. *Amateur Astronomy*, 66.

Genet, Russell M., Johnson, Johnson M., Wallen, Vera. 2010. One-semester astronomical research seminars. In *Small Telescopes and Astronomical Research*, eds. R. Genet, J. Johnson, V. Wallen. Santa Margarita, CA: Collins Foundation Press.

Johnson, Jolyon M. 2008. Double star research as a form of education for community college and high school students. In *Proceedings for the 27th Annual Conference for the Society of Astronomical Sciences*, eds. B. Warner, J. Foote, D. Kenyon, and D. Mais.

Mason, Brian. 2010. *The Washington Double Star Catalog*. Astronomy Department, U.S. Naval Observatory. http://ad.usno.navy.mil/wds/.

Teague, Tom. 2004. Simple techniques of measurement. *Observing and Measuring Visual Double Stars*, ed. Bob Argyle. London: Springer.

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